Prognostics Framework
NDIA SEC Conference, San Diego CA

Presented By:

Ms. Mary Nolan, Giordano Automation Corp.

Authors:

Dr. Li Pi Su, U.S. Army TMDE

Ms. Becky Norman, Giordano Automation Corp.

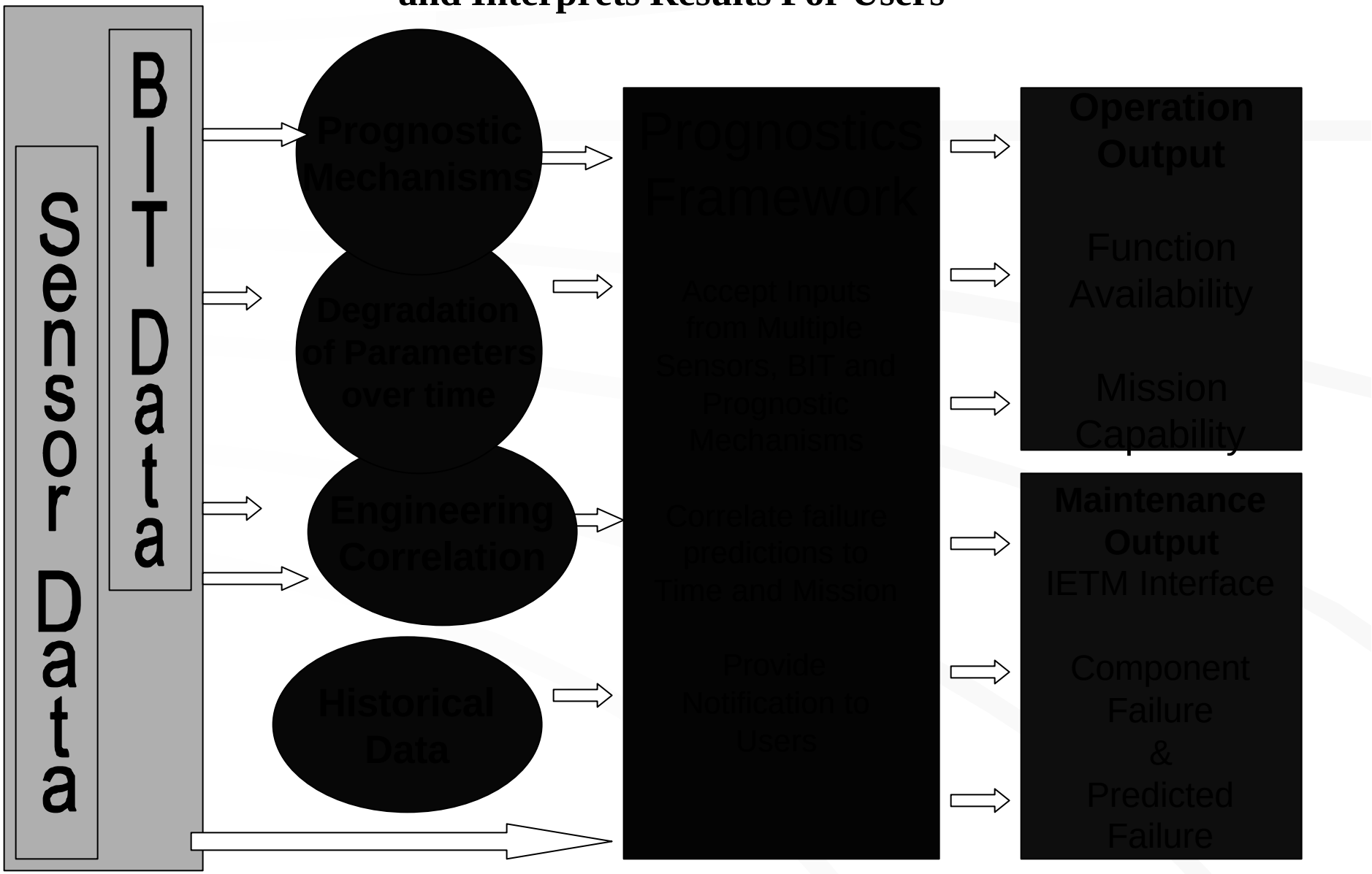
Mr. Greg de Mare, Giordano Automation Corp.

What is the Prognostics Framework?

A System-level prognostic/diagnostic capability

- Integrates sub-system/component specific diagnostic & prognostic software, BIT and parametric data using a “divide and conquer” strategy
- Provides a complete overall system health monitoring and management capability
- Reports on functional capability & mission readiness to aid operations decisions
- Anticipates maintenance workload & provides repair information - interfaces to maintenance aids and support systems

The Prognostics Framework Integrates Prognostics Mechanisms and Interprets Results For Users

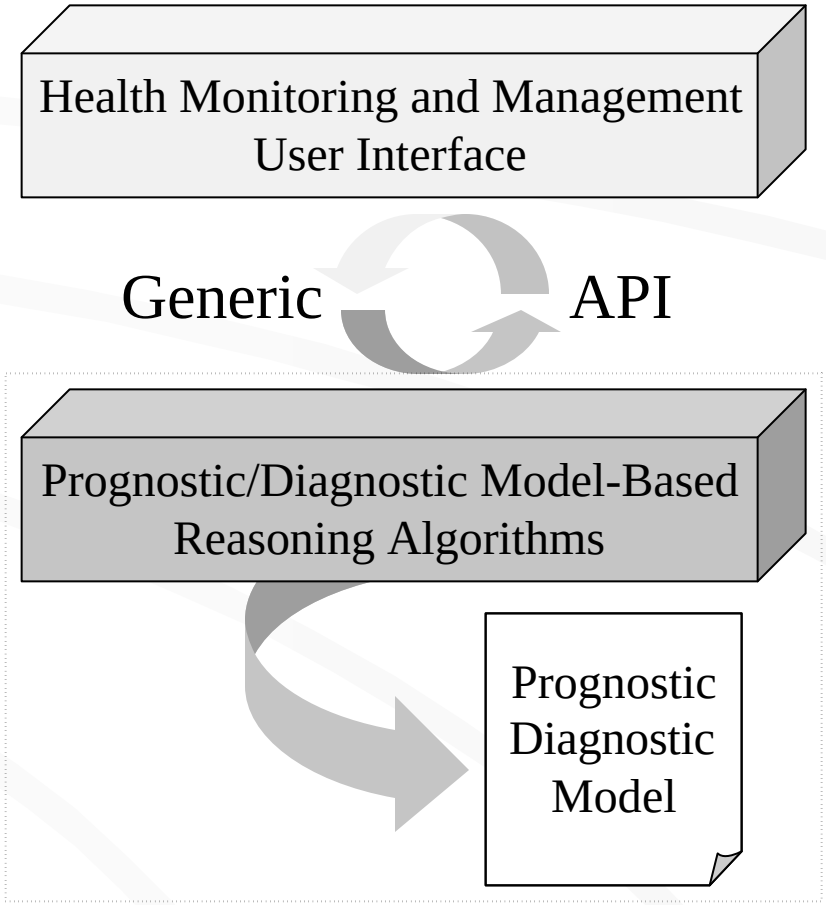


Predictive Techniques Incorporated

- Advanced, Item-Specific Prognostic Mechanisms (ANN, etc.)
- Linear Degradation of Signals / Measurements over time
- Historical Conclusions / Statistics
- Engineering Correlations

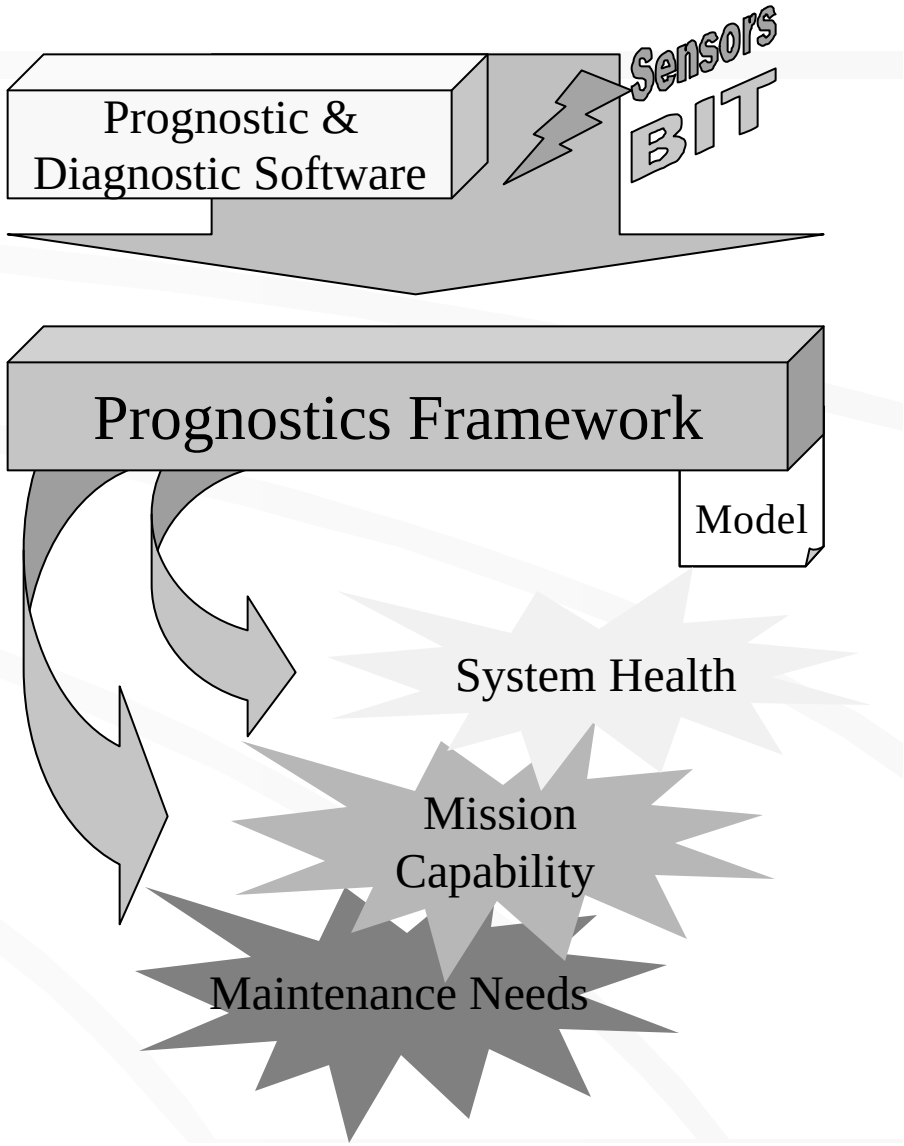
What is the Prognostics Framework?
Generic Open Architecture

- Generically applicable open architecture software system
- Can be applied to existing and new weapon systems
- Can be embedded or off-board (real-time or near real-time)



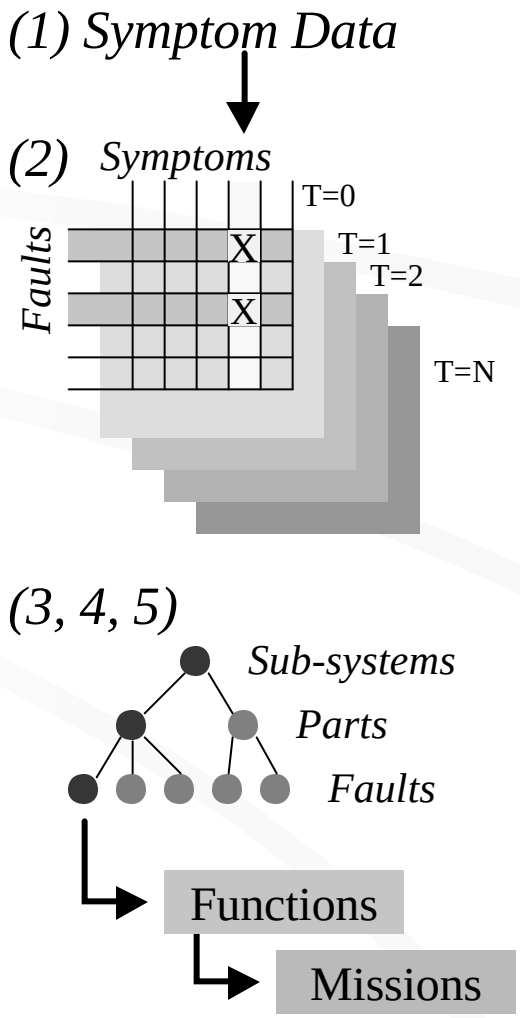
How does the Prognostics Framework work?

- Embedded Environment
  - Monitors data inputs from sensors, BIT, and other prognostic/diagnostic mechanisms
  - Prognoses/Diagnoses failures in real time
  - Provides complete system monitoring
- Off-line Environment
  - Accepts all data available
  - Additional Prognosis/Diagnosis
  - Provides complete system health management
  - Anticipates maintenance needs
  - Integrates logistics software



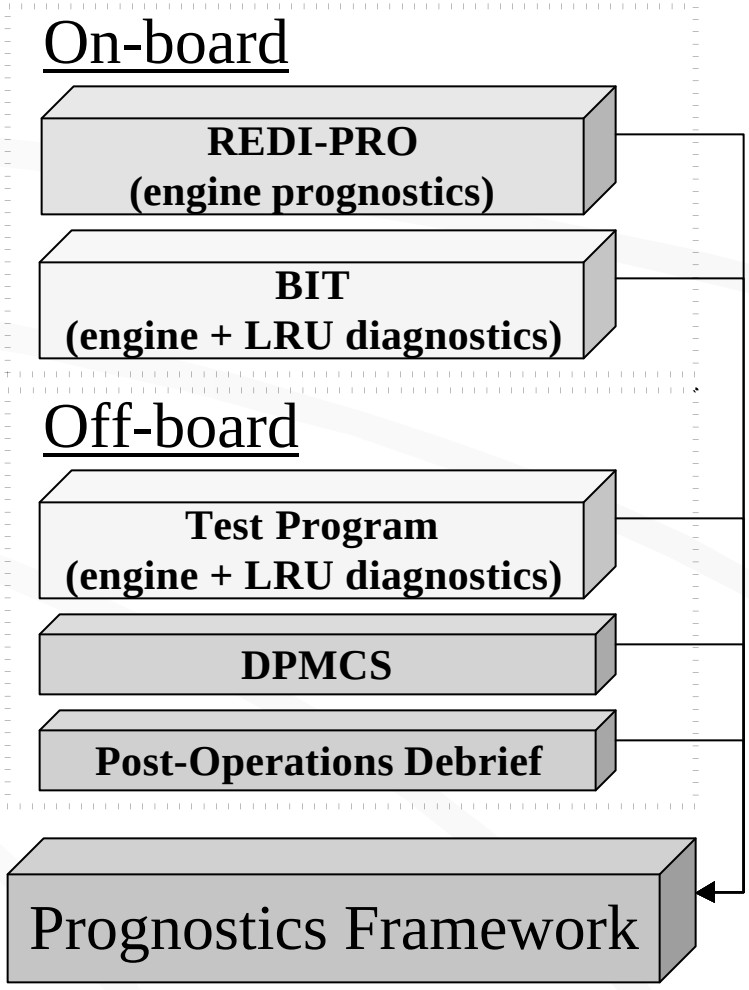
How does the Prognostics Framework reason?

1. Accept prognostic/diagnostic software outputs, BIT and parametric data as *symptoms*
2. Apply model-based reasoning AI algorithms to prognose/diagnose the implication of out of tolerance *symptoms* on each future time point defined in the model
3. Identify the components and sub-systems affected by predicted failures - *sub-system health*
4. Identify the functions and missions affected by predicted failures - *mission readiness*
5. Identify the repair actions needed - *anticipatory maintenance*



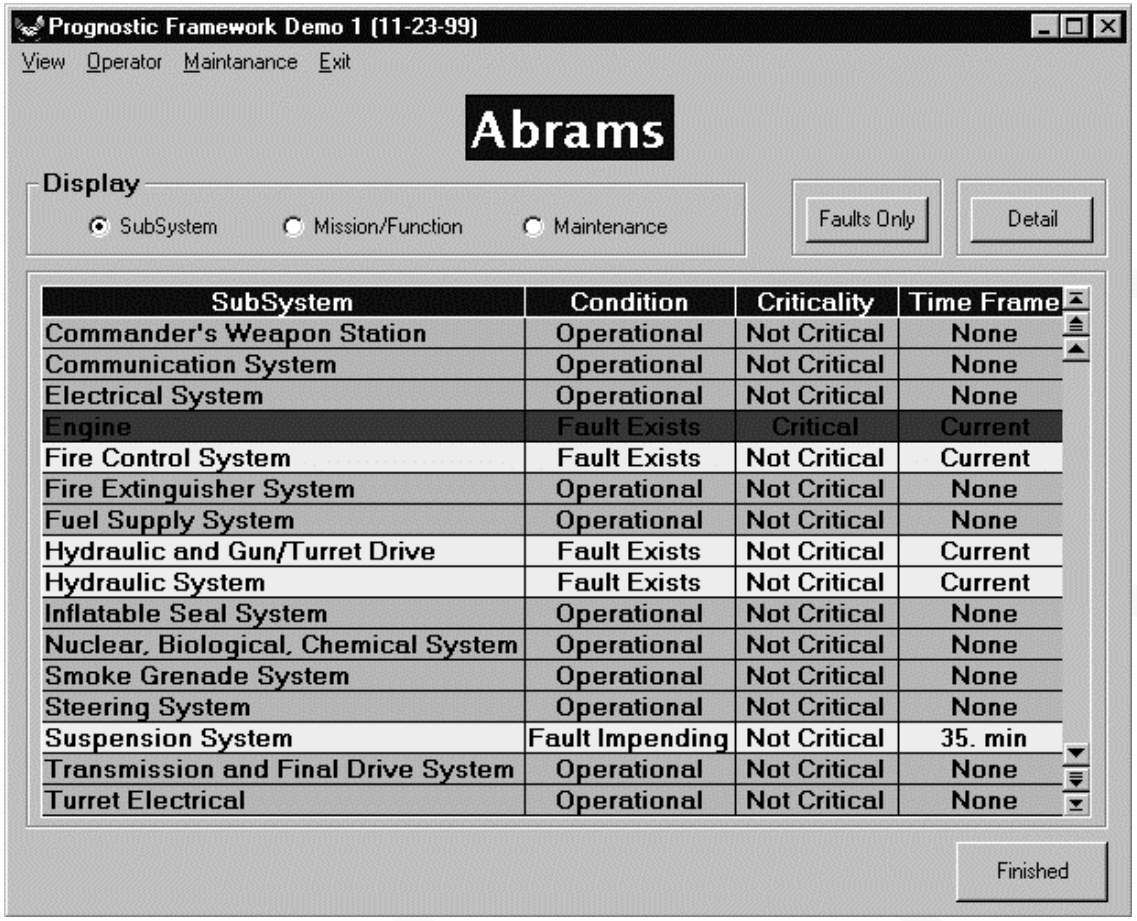
M1A1 Abrams WSSPR Demonstration Prognostic/Diagnostic System Integration

- Engine prognostic inputs from REDI-PRO
- Engine & LRU BIT
- Off-line diagnostic test results
- DPMCS observations from maintenance crew
- Post-Operations Debrief for anomaly filtering
- Prognostic Framework provides additional prognostics/diagnostics



M1A1 Abrams WSSPR Demonstration Health Management

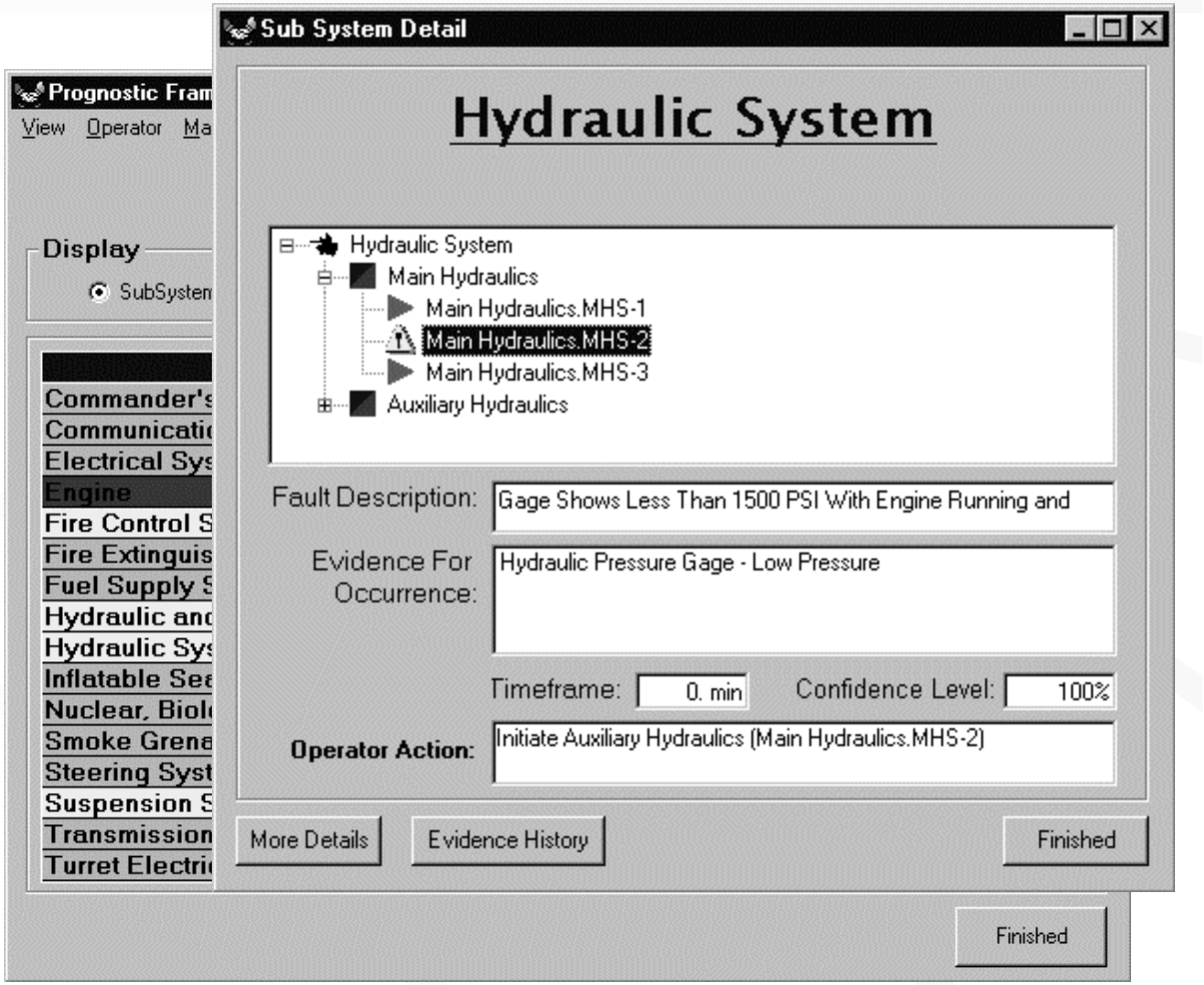
- Provides an at-a-glance view of system health
- sub-system status
- sub-system degradation criticality to operation



SubSystem	Condition	Criticality	Time Frame
Commander's Weapon Station	Operational	Not Critical	None
Communication System	Operational	Not Critical	None
Electrical System	Operational	Not Critical	None
Engine	Fault Exists	Critical	Current
Fire Control System	Fault Exists	Not Critical	Current
Fire Extinguisher System	Operational	Not Critical	None
Fuel Supply System	Operational	Not Critical	None
Hydraulic and Gun/Turret Drive	Fault Exists	Not Critical	Current
Hydraulic System	Fault Exists	Not Critical	Current
Inflatable Seal System	Operational	Not Critical	None
Nuclear, Biological, Chemical System	Operational	Not Critical	None
Smoke Grenade System	Operational	Not Critical	None
Steering System	Operational	Not Critical	None
Suspension System	Fault Impending	Not Critical	35. min
Transmission and Final Drive System	Operational	Not Critical	None
Turret Electrical	Operational	Not Critical	None

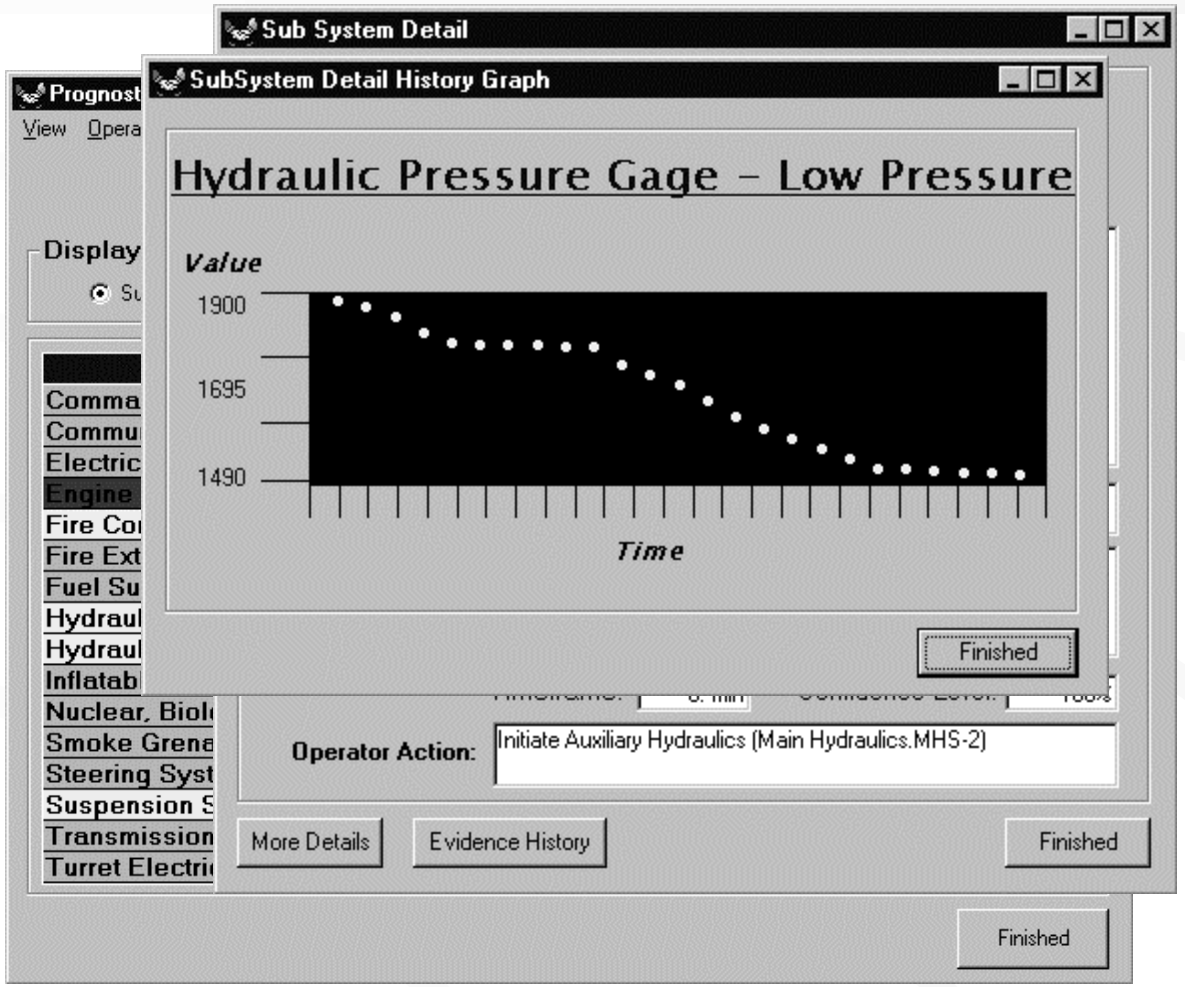
M1A1 Abrams WSSPR Demonstration Health Management

- Sub-system details
- Hierarchical breakout of the sub-system
- Evidence for failure



M1A1 Abrams WSSPR Demonstration Health Management

- Prognostic Framework logs all data received
- Degradation over time

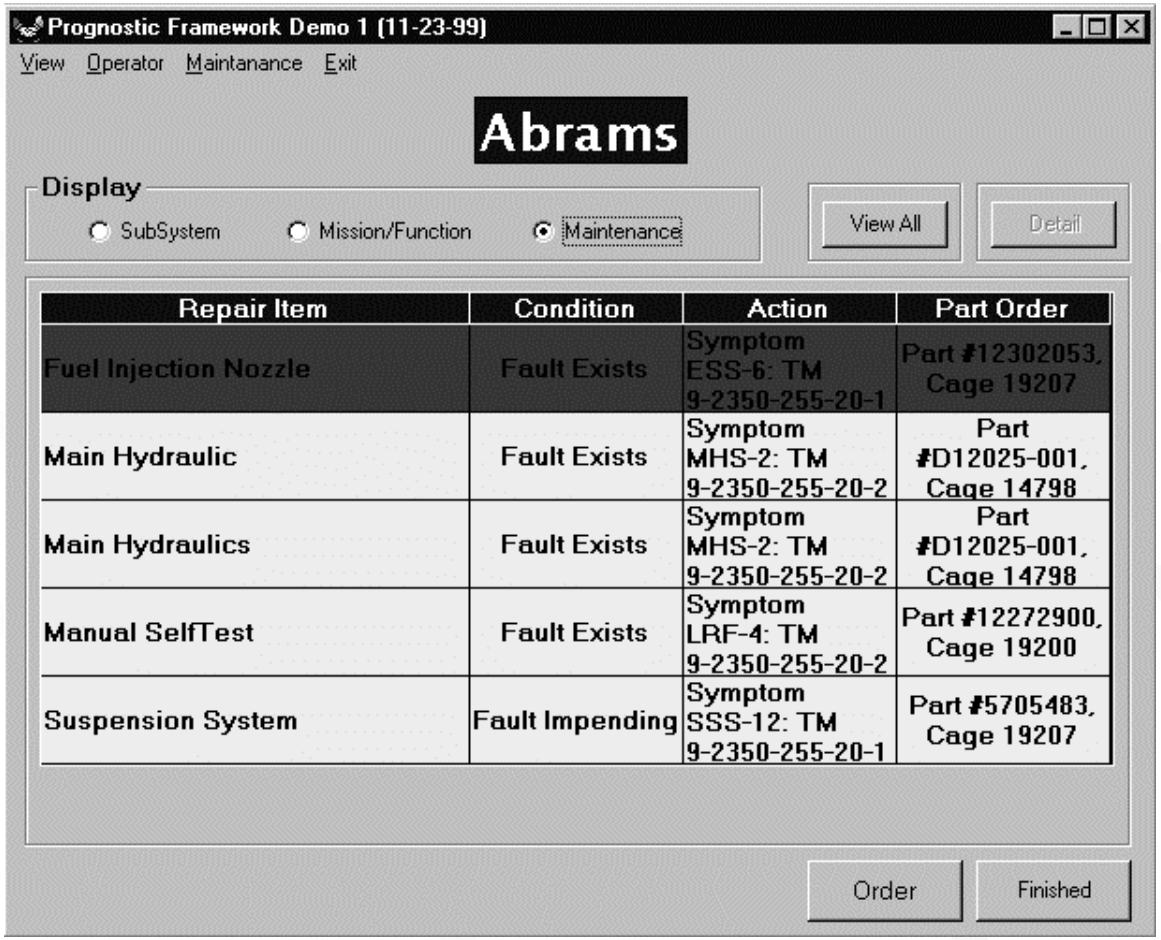


M1A1 Abrams WSSPR Demonstration Health Management

- Impact of Functional degradation on specific missions over time
- What functions are available?
- Mission Readiness

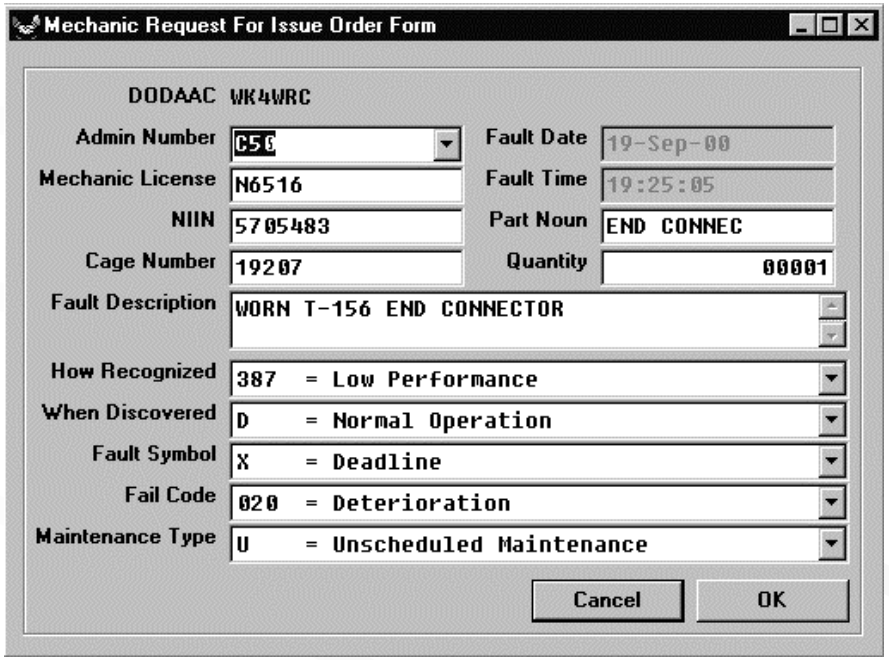
M1A1 Abrams WSSPR Demonstration Maintenance Support

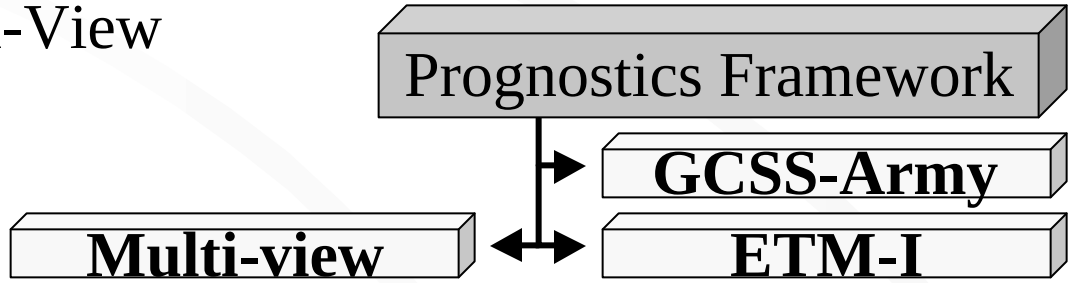
- Current & anticipated maintenance workload
- Supports integrated IETMs, parts ordering
- Preventative maintenance
- Logistics planning
- Repair history is logged



M1A1 Abrams WSSPR Demonstration Maintenance Support

- Prognostic Framework pre-populates the necessary maintenance info
- Interfaces with GCSS-A via DTD/XML tagged data
- Interfaces with ETM-I parts ordering via MS-Access database
- Interfaces with Multi-View logistics network



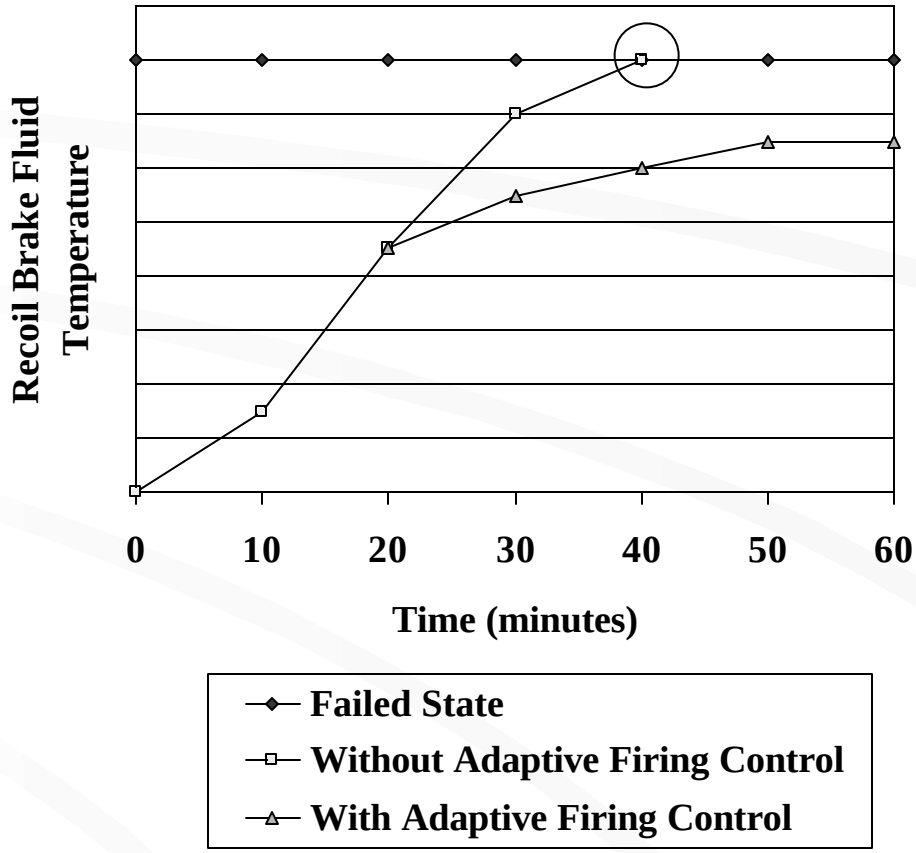


Generalized Information Architecture

- System Design Data (parts, faults)
- Diagnostic/Prognostic Input Descriptions (data definitions, format, location) - REDI-PRO, BIT, Sensor data, etc.
- Diagnostic/Prognostic Preprocessing (mathematical calculations, functions, and filtering)
- Prognostic Times to be Extrapolated during runtime
- Fault/Symptom/Time matrix for failure descriptions
- Operational Support Information - missions, functions, operational actions
- Maintenance Support Information - URL links to other software system, part numbers, ordering information

Army FCS Armament: Viking Program (TC2) Adaptive Firing Control

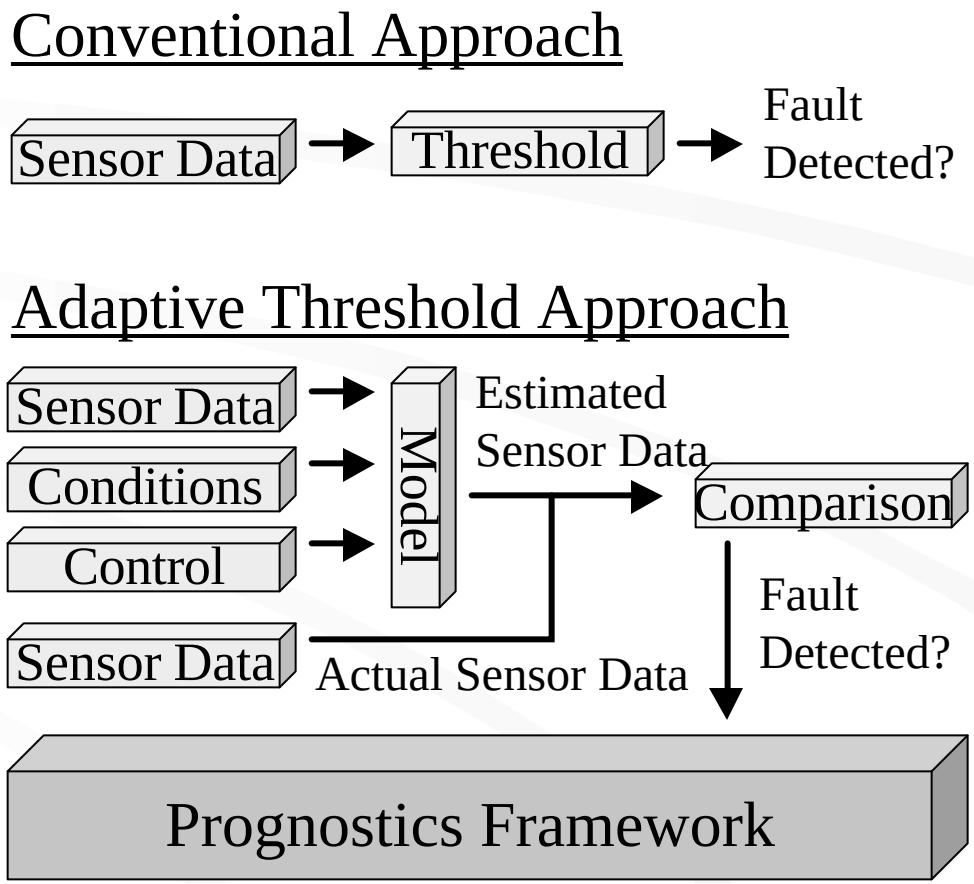
- Monitor armament temperature/stress
- Dynamically adapt rate of fire to avoid an out of tolerance condition
- Manage system degradation
- Maximize armament performance



Real-time system monitoring!

Army FCS Armament: Viking Program (TC2) Integrated Mathematical Model Approach

- Tighter threshold based on estimated sensor reading for specific operating conditions and control commands
- Increased fault detection
- Reduces false alarms and false dismissals
- Enables sensor validation based on inherently redundant sensor info



Flexibility!

Army FCS Armament: Viking Program (TC2) Health Management

- Integrates all system prognostic & diagnostic data
- Provides total armament health monitoring
- Expandable to other FCS sub-systems
- Integrates maintenance requirements - IETM, parts ordering

Expandable!

Summary

- Allows a system to optimize diagnostic capability
- Maximizes the use and effectiveness of BIT/BITE information
- Provides a divide and conquer approach
- Framework allows system managers to CONVERGE on prognostic capability as applications and technologies mature